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Tube bend

The invention relates to a tube piece designed as a tube bend, with at least one bend zone and two outlet zones adjoining the latter on both sides with in each case an end side for the application of pushing rams of an internal high-pressure tool which comprises a die with a recess forming the production cross section.

A method for manufacturing a tube bend is already known from DE 43 22 711 C2. There, the tube section is bent before internal high-pressure forming and upset axially during the internal high-pressure forming. In the process, the tube section undergoes enlargement of the average diameter, this expansion taking place over the entire periphery relative to the central axis. Starting from a round tube cross section and taking the ovality of the cross section in the region of the tube bend brought about during bending into account, the requisite degree of expansion is greater in this region of the tube section in relation to the average degree of expansion.

The invention is based on the object of designing and arranging a tube bend in such a way that stable cross-sectional enlargement is guaranteed during internal high-pressure forming.

According to the invention, the object is achieved by virtue of the fact that the bend zone has a different cross-sectional shape from the outlet zones with an approximately identical flow cross section. The result of this is that the different cross-sectional shape guarantees loading of the tube bend and at the same time a throttling effect of the bend zone is prevented owing to the constant flow cross section.

The axial pushing force exerted on the tube bend during manufacture of this internal high-pressure formed part serves, by virtue of the changed cross-sectional shape in the bend zone, to support the material flow, the changed cross-sectional shape preventing a buckling movement of the tube bend.

For this, it is advantageous if the internal high-pressure tool for manufacturing a tube piece comprises a die with a recess forming the production cross section of the tube bend, the recess having at least one bend zone and two outlet zones adjoining the latter on both sides. In this connection, the recess of the die has a different cross-sectional shape from the outlet zones with an identical cross-sectional area which forms the production cross section. The recess thus formed, or the internal high-pressure tool thus formed, guarantees that the tube bend to be formed is acted on with the requisite axial force without a buckling movement of the tube bend, in particular in the region of the bending plane or of the bend plane, taking place. The minimal degree of forming of the tube bend in the bending plane or bend plane guarantees that the tube bend bears against the recess of the die in the region of the bend zone, so that the pushing movement of the pushing rams does not give rise to a buckling movement, in particular of the tube bend inner side. In the case of internal high-pressure forming as known in the prior art, the inner side of the bend zone, that is the side with the smaller bending radius, would be upset owing to the pressure action alone as the shaped geometry provides for a smaller radius of curvature than the blank. Superimposing the axial pushing movement of the pushing rams necessary in places on this material upsetting leads to failure of the material wall. This is prevented by the tube bend

which bears against the die in the bend zone, the bend being pressed against the die wall on account of the pressure action without upsetting forming having been carried out beforehand.

According to a development, an additional possibility is that an axis of symmetry of the bend zone extends in a bending plane and, in the region of the bending plane, the degree of expansion, as the ratio of the diameter of the component in the bending plane to the diameter of the blank in the bending plane, is between 1 and 1.1. The blank is consequently formed only slightly.

It is furthermore advantageous if the degree of expansion in the region normal to the bending plane is between 1 and 2, in particular between 1.3 and 1.5. In this connection, it is advantageous if the degree of forming increases proportionally starting from the bending plane and reaches its maximum value toward the normal.

For this, it is also advantageous if a number of bend zones and a number of bending planes are provided. In the manufacture of more complex tube bend shapes, a number of bend zones can be provided, each bend zone having its own bending plane. The changing cross-sectional shaping is then adapted according to the course of the bending planes, which guarantees the bearing according to the invention of each bend zone in the region of the respective bending plane.

According to a preferred embodiment of the solution according to the invention, provision is lastly made that a transition of the cross-sectional shape from each outlet zone to the bend zone extends continuously. The continuous cross-sectional adaptation between the

cross-sectional shape of the outlet zones and the cross-sectional shape of the bend zone guarantees minimal flow loss of the media flowing in the tube bend.

It is of particular importance for the present invention that the cross-sectional shape of the bend zone and/or of the outlet zones is of round, oval, rectangular or polygonal design.

In connection with the design and arrangement according to the invention, it is advantageous if a tube piece blank with a diameter A is placed into the recess of the die of the internal high-pressure tool and is acted on by the pushing rams. The tube piece blank is formed or expanded to a desired diameter B in the region of the outlet zones, the tube piece blank being formed or expanded to a desired diameter C in the direction parallel to the bending plane in the region of the bend zone, and the tube piece blank being formed to a desired diameter D in the direction at right angles to the bending plane in the region of the bend zone. The degree of expansion as the ratio of C to A is set between 1 and 1.1. Depending on material and material thickness, a greater degree of expansion, that is greater forming, is possible within the bending plane in the region of the critical bend zone without a buckling movement occurring. In this connection, the workpiece can already bear against the die with the inner wall part, that is with the wall part with the smallest bending radius, in the region of the critical bend zone before the forming process, the minimal forming being generated in the bending plane, in particular in the wall region with the largest bending radius, that is the outer wall region. The critical buckling movement in the inner wall region is consequently prevented. Larger forming operations with

a degree of forming appreciably greater than 1.1 (with regard to the ratio of deformed size to blank size) cannot, however, be realized within the bending plane. In the dimensioning of the degree of expansion, the elastic yield point of the material is also to be taken into account, so that in particular the ratio of C to A can rise above 1.1 and the bearing of the elastically expanded bend zone against the die is nevertheless guaranteed.

It is furthermore advantageous if the degree of expansion as the ratio of D to A is set between 1 and 2, in particular between 1.3 and 1.5. In this connection, a degree of forming of 2, that is a twofold enlargement of the internal high-pressure formed part starting from the blank size, represents for the usual materials a maximum value which, depending on cross-sectional shape change, must be reached to guarantee a constant flow cross section.

Further advantages and details of the invention are explained in the patent claims and in the description and illustrated in the figures, in which:

Fig. 1 shows a longitudinal sectional illustration of a tube piece blank in the die;
Fig. 1b shows the cross section C-C;
Fig. 2 shows a longitudinal sectional illustration of an expanded tube piece in the die, and
Fig. 2b shows the cross section D-D.

A tube bend blank 1 designed as a tube piece blank and illustrated in Figure 1 has an axis of symmetry 1.6 and a diameter A which is constant along the axis of symmetry 1.6. In this connection, the tube bend blank 1 is bent by 90° starting from a cylindrical basic shape and has an axis of symmetry 1.6 which is correspondingly curved by 90°. In this connection, the

radius of curvature of the axis of symmetry 1.6 is approximately 1.5 times the diameter A.

The tube bend blank 1 thus formed has a bend zone 1.1 in the region of the curvature and a first cylindrical outlet zone 1.2 and a second cylindrical outlet zone 1.3. At the end of the two outlet zones 1.2, 1.3, the tube bend blank 1 comprises a first end side 1.2′ and a second end side 1.3′, to which pushing rams 2, 3 of an internal high-pressure forming device are connected, which on the one hand serve for axial pressure action and on the other hand introduce the pressure medium. The tube bend blank 1 is arranged within a die 4 which comprises a recess 4.5 for receiving the tube bend blank 1. The tube bend blank 1 is coupled to the pushing rams 2, 3 at its two end sides 1.2′, 1.3′. In addition to the recess 4.5, the die 4 comprises a further recess 6 which adjoins the recess 4.5 radially and, according to Figure 2, guarantees a special shaping geometry of the tube bend blank 1.

In the region of the bend zone 4.1, the recess 4.5 has in the bending plane or bend plane the same diameter A as the tube bend blank 1. According to the cross-sectional illustration C-C, the recess 4.5 of the die 4 has an appreciably larger diameter D (according to section D-D) in the direction perpendicular to the bending plane or bend plane.

In the region of the two outlet zones 4.2, 4.3, the recess 4.5 of the die has, differing from the bend zone 4.1, a cylindrical basic shape (not illustrated further) corresponding to the tube bend blank 1. In the region of the two outlet zones 4.2, 4.3, the recess 4.5 has a larger diameter B (according to Figure 2) than the tube bend blank 1. Consequently, the tube bend blank 1 bears linearly with the bend zone 1.1 against

the die 4 or its bend zone 4.1 in the bending zone next to the two pushing rams 2, 3.

In this connection, the cross-sectional shape of the recess 4.5, which is circular in the region of the two outlet zones 4.2, 4.3, changes in the region of the bend zone 4.1 according to Figure 1b to an oval cross-sectional shape with the same cross-sectional area 4.4.

According to Figure 2, the tube bend blank 1 is shaped into the tube bend and has the shape of the recess 4.5. In addition to the additional radial shaping 5 in the region of the second recess 6 of the die 4, the tube bend blank 1 has in the region of the two outlet zones 1.2, 1.3 been enlarged to the diameter of the recess 4.5 and has in the region of the two outlet zones 1.2, 1.3 a corresponding circular cross-sectional shape (not illustrated further). In the region of the bend zone 1.1, the tube bend blank 1 has according to Figure 2b been shaped ovally according to the oval shape of the recess 4.5, the degree of expansion being designed to be equal to 1 parallel to the bending plane and to increase to a minimum dimension, that is maximum forming, in the direction at right angles to the bending plane.

During the shaping operation, the tube bend blank 1 is acted on with axial pressure via the pushing rams 2, 3, with which sufficient material flow for the forming, in particular in the region of the second recess 6 or other recesses not illustrated here, is guaranteed. During the axial pressure action by the pushing rams 2, 3, the tube bend bears against the die 4 or its bend zone 4.1 with the bend zone 1.1 in the bending plane.